Biolife 5(4):428-436
AN INTERNATIONAL QUARTERLY JOURNAL OF BIOLOGY & LIFE SCIENCES
ISSN (online): 2320-4257
www.biolifejournals.com
BIOLIFE ORIGINAL ARTICLE

Allelopathic Effect of Neem (*Azadirachta indica* A. Juss) Aqueous leaf extract on The Germination and Growth of Some selected Crops and Weeds

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ABSTRACT

The present study was conducted to investigate the allelopathic effect of Neem leaf aqueous extract on the seed germination and growth of two crops (*Zea mays* L. and *Triticum aestivum* L.) and two weeds (*Bidens pilosa* L. and *Portulaca oleracea* L.). Also, the total phenols, flavonoids, saponins, tannins and alkaloids, were determined in the Neem leaves. The results indicated that the aqueous extract of Neem plant showed a remarkable allelopathic effect on the growth and germination of all test plant species. The effectiveness of the extract was much higher on the root growth than the shoot of test plants. The radicle length was obviously decreased with increasing the concentration of the extract in all test plants. The present study indicated that the tested weeds were more sensitive to Neem extract than the tested crops. Moreover, the shoot length of *Zea mays* showed stimulation in all extracts after 10 days. The inhibition of *Zea mays* shoot length occurred after 30 days in all extracts. The allelochemicals such as total phenols, flavonoids, saponins, tannins and alkaloids recorded the values 318 mg/gm gallic acid, 269.3 mg/gm rutin, 2.07 gm % saponins and 1.77 gm % for tannins and alkaloids respectively in the Neem leaves. The results of the present study elucidated that stimulatory and inhibitory effect of Neem aqueous leaf extract may be due to the presence of such allelochemicals.

Kew word: Neem, Allelopathy, Inhibitory response, Allelochemicals

INTRODUCTION

Allelopathy refers to direct or indirect stimulatory or inhibitory effects of one plant on another through release of chemical compounds into the environment (Patterson, 1983). Compounds with allelopathic activity are present in many plants and in different plant organs, including stems, leaves, buds, flowers and fruits (Indrajit, 1996 and Ashrafi, *et al*., 2007). These allelopathic compounds could be used as tools for herbicide production. Natural compounds are considered to be more environmentally benign than most synthetic herbicides (Duke *et al.*, 2000 and Macias *et al.*, 2007).

How to Site This Article:
Hoda A. Abd El-Hamid*, Lamis M. N. Ibrahim, Mohamed Y. Ammar and Mohamed A. Helmy (2017). Allelopathic Effect of Neem (*Azadirachta indica* A. Juss) Aqueous leaf extract on The Germination and Growth of Some selected Crops and Weeds. *Biolife*. 5(4), pp 428-436.

DOI: 10.5281/zenodo.7376409
Received: 2 October 2017;
Accepted; 20 November 2017;
Available online : 3 December 2017

Application of allelopathy has shown tremendous scope in agricultural pest management (Farooq *et al*., 2011). A number of higher plants were observed to possess allelopathic potential (Kohli *et al*., 1998). They release a diversity of allelochemicals into the environment, including phenolics, alkaloids, long-chain fatty acids, terpenoids and flavonoids. These allelochemicals usually, inhibit the germination or growth of neighboring plants, although sometimes they may show a stimulatory effect (Chou, 1995).

Neem (*Azadirachta indica*. A. Juss) belongs to the family Meliaceae. It is an evergreen tree native to Indo-Pakistan subcontinent (Cheneya and Knudson, 1988). Neem has been used in households for giving bath to newly born infants, protect people from insect bites and cure skin ailments and used as traditional medicine for the treatment of various diseases since very ancient times (Isman *et al.*, 1990). Now it is widely used in

toothpastes, soaps and lotions as well as a biological insecticide. These properties have been attributed to hundreds of chemicals present in it. Active components isolated from neem include triterpenoids and azadirachtin (NRC, 1992).

Neem tree has been shown to inhibit germination of some crops such as carrot, rice, sesame and weeds such as *Echinochloa crus-galli* (Xuan *et al*., 2004). It reduces the germination of wheat and its weeds (Shahid and Horoon, 2006). The extract of neem leaves exhibits strong phytotoxicity and possesses the growth inhibitory ability of noxious weeds (Salam and Noguchi 2010). Rao and Mamta (2013) reported that the aqueous extracts of Neem and Eucalyptus showed a remarkable allelopathic effect on the growth and germination of wheat. Also, Mishra (2014) found that neem leaf extract inhibit the germination, root and shoot elongation of some agricultural crops. Noguchi *et al*. (2014) recorded nimbolide B and nimbic acid B as phytotoxic substances which inhibit the growth of cress and barnyard grass.

Wheat (*Triticum aestivum* L.) and Corn (Zea mays L.) belong to family poaceae. They are the most important cereal crops growing in Egypt. Wheat is one of the first domesticated food crops and is a basic staple food of the majority of the population in Egypt and many regions of the world. Also, corn is used as a food for human consumption and also as a feed grain for animals in Egypt.

Portulaca oleracea L. (Family Portulacaceae) and *Bidens pilosa* L. (Family Asteraceae) are common weeds in Egypt and various countries of the world. These weeds show quick growth and have very high competition with the crops for food and reproduction. They dominate many weed communities in summer crops and orchards in Egypt (Abd El- Hamid, 2005).

However, Neem is considered as promising source of herbicides; the process of allelopathy can cause a deleterious effect on the crop productivity if the allelopathic plants are growing in proximity with these crops. So it must be taken in consideration the effect of Neem plant on crops when using Neem plant as herbicides. Therefore, The objective of this work is to determine the allelopathic effect of neem on germination and seedling growth of some selected crops (*Triticum aestivum and Zea mays*) and some weeds (*Portulaca oleracea* and *Bidens pilosa*).

MATERIAL AND METHODS

Collection of plant materials:

Fresh undamaged mature leaves of *Azadirachta indica* were collected from El - Ersal District (Lat. 30º 36´ N; Long 32º 18´ E), Ismailia city, Egypt in August 2015, then identified in Botany Department Herbarium, Faculty of Science, Suez Canal University. These leaves were air dried at room temperature for two weeks and stored in 2 C^0 temperatures.

Preparation of Aqueous Extracts:

According to Jafari *et al*. (2007) and Lawan *et al*. (2011), the air dried leaves were ground to fine powder using mortar and pestle. Ten grams of the powder were soaked in one liter of distilled water for 24 hours. The solution was filtered through Whatman No.2 filter paper. Three concentrations (10, 30 and 50 %) were prepared from the leaf extract and stored separately in conical flasks. Distilled water was considered as control (0 %).

Collection and sterilization of tested seeds:

The grains of *Zea mays* and *Triticum aestivum* used in this experiment were obtained from Agriculture Research Center in Ismailia, Egypt, while the seeds of *Bidens pilosa* and *Portulaca oleracea* were collected from the weed communities associated with crops of Ismailia governorate. Seeds were sterilized with 1% sodium hypochlorite for about 30 minutes, then rinsed with distilled water for several times to remove excess of chemicals.

Bioassay for germination studies:

The experiment covered a period of five days to show the effect of aqueous extract of Neem on the germination (radicle length) of *Zea mays*, *Triticum aestivum, Bidens pilosa* and *Portulaca oleracea* seeds. The germination test was carried out in sterile Petri-dishes (12 cm in diameter) using a Whatman No.2 filter papers. The leaf aqueous extract of different concentration (0, 10, 30 and 50%) was daily added to each corresponding Petri-dishes (Lawan *et. al*., 2011).Ten grains of *Zea mays* and *Triticum aestivum,* twenty seeds of *Bidens pilosa*, and thirty seeds of *Portulaca oleracea* were randomly placed in the petri-dishes. Three replicates were done. The petri- dishes were then placed in an incubator at 25C^0 temperature. Seeds were considered germinated when radicle emergence. To assess the effect of different extracts, the radicle length was measured with a measuring scale at 24 hour intervals over a 5- day period. The inhibition percentages were calculated according to the formula described by Sundra and Pote (1978).

Inhibition percentage = $100 - (E_2 \times 100/E_1)$

Where,

E1 = Response of control plant.

E2 = Response of treatment plan

Seedling growth test:

The experiment was conducted to study the effect of aqueous leaf extracts of Neem on the growth of of *Zea mays*, *Triticum aestivum, Bidens pilosa* and *Portulaca oleracea* plants. The seeds were sown at equal depths in the pots of 14 cm in diameter filled with sandy soil. The pots were kept in a greenhouse at temperature ranged from 25- 30 C^0 and the plants in the pots were treated with leaf aqueous extracts of the selected concentrations at regular intervals. Meanwhile, the plants in the control pot were treated with distilled water. Only five plants of *Zea mays* and *Triticum aestivum* and ten plants of *Bidens pilosa* and *Portulaca oleracea* were kept in each pot and the others were eliminated in order to avoid intraspecific competition between the plants for limited

supply of nutrients. The heights were measured with the help of a ruler over a thirty days period at an interval of ten days (Rao and Mamta, 2013). The shoot length inhibition percentages were calculated according to the above formula described by Sundra and Pote (1978).

Phytochemical analysis

Estimation of Total Phenolic Content

The amount of total phenols in extract was determined spectrophotometrically with the Folin Ciocalteu reagent. Gallic acid was used as a standard and the total phenols were expressed as µg/mg gallic acid equivalent (GAE) (Chun *et al.,* 2003 and Maurya and Sing, 2010).

Estimation of Total Flavonoid Content

The amount of Total Flavonoid content in extract was determined by aluminum chloride assay through Colorimetric method (Samatha *et al.*, 2012 and Han and May, 2012). Rutin was used as standard compound for the quantification of total Flavonoid. Total flavonoid content was expressed as mg rutin/g dry weight (mg rutin/g DW), through the calibration curve of Rutin.

Estimation of Total Tannins

Tannin content was estimated by Gravimetric Method (Copper Acetate Method. This method depends on quantitative precipitation of tannin with copper acetate solution, igniting the copper tannate to copper oxide and weighing the residual copper oxide (Ali *et. al*., 2011).

Estimation of Total Saponins

Saponin was determined according to Obadoni and Ochuko (2001) and Okwu and Ukanwa (2007).

Estimation of Total Alkaloids

Alkaloids were estimated by Gravimetric Method according to Woo *et al.*, (1977).

Statistical analysis

Descriptive statistics and Box plot were carried out by Minitab software, version 17.0.

RESULTS

Effect of Neem leaf extract on radicle growth of test plants

The effect of aqueous extract of Neem leaves on radicle growth of *Triticum aestivum*, *Zea mays*, *Bidens pilosa* and *Portulaca oleracea* are shown in **Table-1** and **Fig-1.** It was observed that control showed maximum radicle growth in all tested plants. The aqueous extract of Neem leaves exhibited a marked radicle growth inhibition which is depending upon Neem extract concentration. The inhibitory effect of the extract increased with increasing concentration of the extract. The highest inhibition percentage (78.32%) on radiclel growth of *Triticum aestivum* was seen in plants treated with 50% concentration of aqueous Neem leaf extract after 120 hrs. while, the lowest inhibition percentage (16.28 %) was observed in *Triticum aestivum* plants treated with 10% concentration after 24 hrs. *Zea mays* started germination after 48 hrs. The highest inhibitory effect (81.3%) on radicle growth of *Zea mays* was seen in plants treated with 50% concentration after120 hrs. but the lowest inhibition percentage (16.27) was seen in plants treated with 10% concentration after 48 hrs.

Similarly, the two tested weeds (*Bidens pilosa* and *Portulaca oleracea*) exhibited the highest inhibitory effects with the highest concentration of aqueous Neem leaf extract. The data in **Table 1** showed that the highest inhibitory effect of aqueous Neem leaves extract on radicle growth of *Portulaca oleracea* was (88.75%) seen in plants treated with 50% concentration after 120 hrs. while, the lowest inhibition percentage (24.53%) was observed in *Portulaca oleracea* plants treated with 10% concentration after 96 hrs. Also, the highest inhibition percentage (83.43%) was shown in *Bidens pilosa* plants treated with 50% concentration after120 hrs. but the lowest (15.47) was observed in plants treated with 10% concentration after 120 hrs. The results showed that the two tested weeds (*Bidens pilosa* and *Portulaca oleracea*) were more sensitive to the aqueous Neem leaves extract concentrations as they showed higher inhibition percentage than that of the two crops (*Triticum aestivum* and *Zea mays*).

The Boxplot in **Fig-1** represents the variability in the radicle length of treated plants with Neem aqueous extract. In case of the two weeds (*Bidens pilosa* and *Portulaca oleracea*), it was noticed that both of these plants were more affected by the extracts with the different concentrations. There were no high variations in the radicle length readings of these plants. The median value in *Bidens pilosa* was 0.13, but the median value in *Portulaca oleracea* was 0.09. There was an outlier symbol in the readings of *Portulaca oleracea* radicle length equal 0.80 appear in the Boxplot, which can be neglected.

In case of the two crops (*Zea mays* and *Triticum aestivum*), it was noticed that both of these plants were relatively affected by the extracts with the different concentrations. There were high variations in the readings of their radicle length. The median value in *Zea mays* was 2.16 and 1.92 in *Triticum aestivum*. This means that *Triticum aestivum* was affected by Neem extract more than *Zea mays*. There were two outlier symbols in the readings of *Triticum aestivum* equal 5.78 and 7.38, and two other outlier symbols in the readings of *Zea mays* equal 7.52 and 11.23 appear in the Boxplots, which can be neglected.

Effect of Neem leaf extract on shoot length of test plants

The averages shoot length and inhibition percentage of the test plants are shown in **Table-2** and **Fig-2.** The highest shoot length of *Triticum aestivum* was

Table-1. Radicle length (cm) and inhibition percentage (%) of *Zea mays, Triticum aestivum, Bidens pilosa* and *Portulaca oleracea* treated with aqueous extract of Neem

Test plant	Time (hour)	Extract concentration (%)						
		Control	10 %		30 %		50 %	
		Radicle Length (cm)	Radicle Length (cm)	Inh. (%)	Radicle Length (cm)	Inh. (%)	Radicle Length (cm)	Inh. (%)
T. aestivum	24	0.43 ± 0.05	0.36 ± 0.05	16.28	0.21 ± 0.04	51.16	0.16 ± 0.05	62.79
	48	2.00 ± 0.07	1.32 ± 0.11	34.00	1.38 ± 0.11	31.00	1.18 ± 0.11	41.00
	72	4.54 ± 0.18	2.44 ± 0.14	46.26	2.16 ± 0.09	52.42	1.70 ± 0.15	62.56
	96	5.78 ± 0.14	3.28 ± 0.14	43.25	2.80 ± 0.12	51.56	1.84 ± 0.17	68.17
	120	7.38 ± 0.23	2.73 ± 0.16	63.01	2.20 ± 0.24	70.19	1.60 ± 0.17	78.32
Z. mays	24	0.00 ± 0.00	0.00 ± 0.00	0.00	0.00 ± 0.00	0.00	0.00 ± 0.00	0.00
	48	1.66 ± 0.05	1.39 ± 0.05	16.27	1.31 ± 0.05	21.08	1.00 ± 0.04	39.76
	72	4.53 ± 0.14	2.80 ± 0.09	38.19	2.28 ± 0.09	49.67	2.03 ± 0.08	55.19
	96	7.52 ± 0.16	3.53 ± 0.08	53.06	2.78 ± 0.11	63.03	2.22 ± 0.08	70.48
	120	11.23 ± 0.19	4.16 ± 0.16	62.96	2.88 ± 0.10	74.35	2.10 ± 0.14	81.30
B. pilosa	24	0.00 ± 0.00	0.00 ± 0.00	0.00	0.00 ± 0.00	0.00	0.00 ± 0.00	0.00
	48	0.00 ± 0.00	0.00 ± 0.00	0.00	0.00 ± 0.00	0.00	0.00 ± 0.00	0.00
	72	0.26 ± 0.04	0.15 ± 0.07	42.31	0.12 ± 0.08	53.85	0.00 ± 0.00	0.00
	96	1.53 ± 0.06	1.08 ± 0.07	29.41	0.96 ± 0.09	37.25	0.60 ± 0.46	60.78
	120	1.81 ± 0.09	1.53 ± 0.12	15.47	0.72 ± 0.05	60.22	0.30 ± 0.15	83.43
P. oleracea	24	0.00 ± 0.00	0.00 ± 0.00	0.00	0.00 ± 0.00	0.00	0.00 ± 0.00	0.00
	48	0.17 ± 0.08	0.10 ± 0.27	41.1	0.06 ± 0.02	64.71	0.04 ± 0.04	76.47
	72	0.27 ± 0.08	0.20 ± 0.38	25.93	0.07 ± 0.03	74.07	0.05 ± 0.00	81.48
	96	0.53 ± 0.08	0.40 ± 0.53	24.53	0.09 ± 0.02	83.02	0.07 ± 0.04	86.79
	120	0.80 ± 0.11	0.50 ± 0.59	37.50	0.11 ± 0.04	86.25	0.09 ± 0.00	88.75

observed in control which was 8.2 cm after 10 days, 18.4cm after 20 days and 22.5cm after 30 days. While, the highest inhibition percentages was 35.37%, 10.98% and 23.17 after 10 days in *Triticum aestivum* plants treated with 10%, 30% and 50% respectively. All concentrations of Neem aqueous extracts induced a pronounced reduction in the shoot length of *Triticum aestivum* at all days of experiment relative to control. On the other hand, the concentrations 10%, 30% and 50% stimulated the shoot length of *Zea mays* compared to control after 10 days, while 30% and 50% concentrations stimulated the shoot length after 20 days. The inhibitory effect on the shoot length of *Zea mays* was observed after 20 days with 10% concentration which was 4.19%, while, after 30 days all concentrations of Neem aqueous extracts caused a reduction in the shoot length of *Zea may.*

In respect to the test weeds *(Portulaca oleracea* and *Bidens pilosa*), the maximum shoot length was observed in control which was 3.5, 7 and 7.4 cm after 10, 20 and 30 days respectively for *Bidens pilosa* and 0.32 cm after 10 days, 0.55cm after 20 days and 1.4cm afer 30 days for *Portulaca oleracea*. On the other hand, the inhibitory effect on test weeds was induced with extract treatment after 10 days. The highest inhibition percentage on the shoot length of *Bidens pilosa* was seen in plants treated with 50% concentration which was 28.57% after 20 days. Also the highest inhibition

percentage (54.55%) was observed in shoot length of *Portulaca oleracea* treated with 10% and 50% concentrations after 20 days.

The Boxplot in **Fig-2** represents the variability in the shoot length of treated plants with Neem aqueous extract. In case of the two weeds (*Bidens pilosa* and *Portulaca oleracea*), it was noticed that both of these plants were more affected by the extracts with the different used concentrations. There were no high variations in the shoot length readings of these plants. The median value in *Bidens pilosa* was 5.1, but that in *Portulaca oleracea* was 0.305. There was an outlier symbol in the readings of *Portulaca oleracea* shoot length equal 1.40 appear in the Boxplot, which can be neglected. In case of the two crops (*Zea mays* and *Triticum aestivum*), it was noticed that both of these plants were relatively affected by the extracts with the different concentrations. There were high variations in

Figure-1. Boxplots showed variations in radicle length of *Zea mays, Triticum aestivum, Bidens pilosa* and *Portulaca oleracea* treated with aqueous extract of Neem.

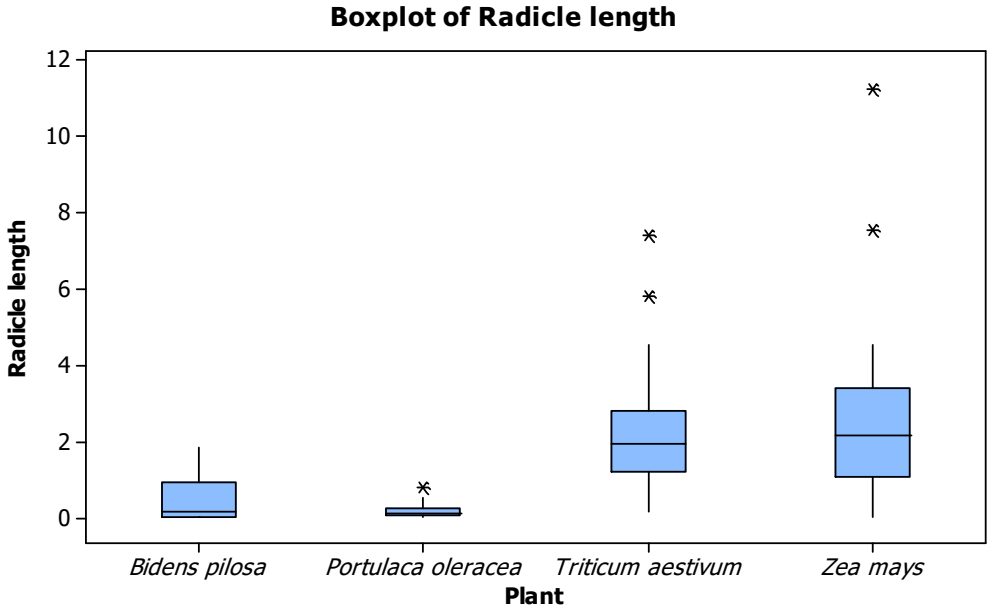


Table-2. Shoot length (cm) and inhibition percentage (%) of *Zea mays, Triticum aestivum, Bidens pilosa* and *Portulaca oleracea* treated with aqueous extract of Neem

Test plant	Extract conc.	Time (day)					
		10		20		30	
		Shoot Length (cm)	Inh. (%)	Shoot Length (cm)	Inh. %)	Shoot Length (cm)	Inh. (%)
T. aestivum	**Cont.**	8.20 ± 0.12	0.00	18.4 0 ± 0.12	0.00	22.50± 0.29	0.00
	10 %	5.3 0 ± 0.2	35.37	17.00 ± 0.38	7.61	21.00± 0.75	6.67
	30 %	7.30 ± 0.2	10.98	17.00 ± 0.40	7.61	20.10± 0.09	10.67
	50 %	6.30 ± 0.17	23.17	17.0 0 ± 0.29	7.61	20.50± 0. 58	8.89
Z. mays	**Cont.**	9.78 ± 0.57	0.00	17.89 ± 1.67	0.00	30.16± 0.10	0.00
	10 %	11.04 ± 0.87	-12.88	17.14 ± 2.81	4.19	25.63± 0.36	15.02
	30 %	12.27 ±0.18	-25.46	21.19 ± 0.46	-18.45	25.41± 0.52	15.75
	50 %	11.93 ± 1.03	-21.98	18.08 ± 0.63	-1.06	25.16± 0.10	16.58
B. pilosa	**Cont.**	3.50 ± 0.29	0.00	7.00 ± 0.12	0.00	7.40± 0.23	0.00
	10 %	3.00 ± 0.29	14.29	6.20 ± 0.23	11.43	6.80± 0.61	8.11
	30 %	3.50 ± 0.58	0.00	5.20 ± 0.23	25.71	5.90± 0.06	20.27
	50 %	4.00 ± 0.58	-14.29	5.00 ± 0.29	28.57	5.80± 0.23	21.62
P. oleracea	**Cont.**	0.32 ± 0.06	0.00	0.55 ± 0.03	0.00	1.40± 0 .12	0.00
	10 %	0.20 ± 0.03	37.5	0.25 ± 0.03	54.55	0.80± 0.03	42.86
	30 %	0.20 ± 0.01	37.5	0.40 ± 0.06	27.27	0.70± 0.06	50.00
	50 %	0.17 ± 0.02	46.87	0.25 ± 0.01	54.55	1.20± 0.12	14.29

the readings of their shoot length. The median values in *Zea mays* and *Triticum aestivum* was 16.24 and 17 respectively. This means that *Triticum aestivum* affected by Neem extract more than *Zea mays*.

Bioactive chemical constituents in Neem plant.

The phytochemical analysis of *Azadirachta indica* (Neem) is presented in Table-3. The Neem leaves contained high contents of phenolic acids and flavonoids (318 mg/gm gallic aeid and 269.3 mg/gm rutin respectively). On the contrary, it contained low contents of saponins (2.07 gm %), tannins and alkaloids (1.77 gm %, for each).

Table-3. Bioactive chemical constituents in Neem plant

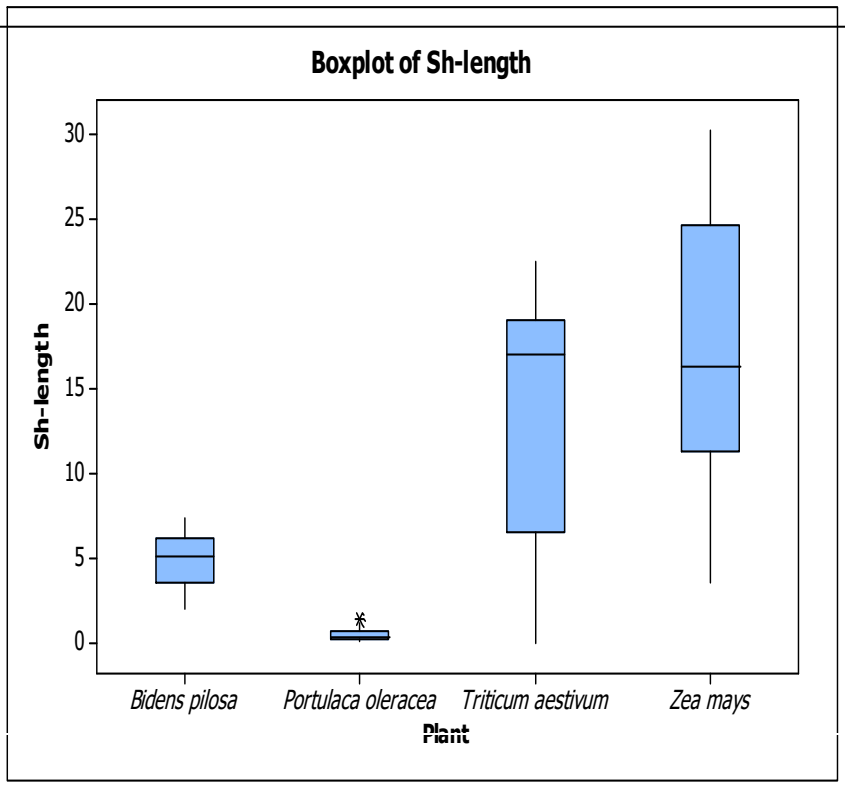
Constituents	Concentration
Total phenolic acids (mg/gm Gallic acid)	318±0.67
Total flavonoids (mg/gm rutin)	269.3±0.708
Total Saponins (gm %)	2.07±0.167
Total Alkaloids (gm %)	1.77±0.13
Total Tannins (gm %)	1.77±0.063

DISCUSSION

The above results indicated that the different concentrations of Neem leaf extracts inhibited the germination of the tested weeds (Bidens pilosa and Portulaca oleracea) and the tested crops (*Triticum aestivum* and *Zea mays*). It was also observed that the allelopathic effect of Neem extract is more prominent in the observation of radicle growth. The radicle length was obviously decreased with increasing the concentration of the extract in all test plants. Moreover, our results showed more inhibitory effects on root than shoot length. The present findings corroborate the earliest results by Salam and Noguchi (2010) who demonstrated that the effectiveness of the Neem extract was much higher on the root growth than the shoot growth of the test plants. Similar results were also obtained by Lawan et al. (2011) in which it was cleared that the reduction in root length of some cowpea varieties treated with aqueous extract of Neem was much pronounced than that of germination and shoot length. Recently, Shruthi et al. (2014) reported that the aqueous leaf extract of Neem caused more inhibitory effects on root than shoot length of Vigna radiata. The higher root growth inhibition with higher extract concentration might be due to the direct contact between the root and phytotoxic substances present in the aqueous extract and the greater permeability of these substances to root tissues than that of shoot tissues (Nishida et al., 2005). These phytotoxic substances may inhibit cell division which is highly active at meristematic tissue at the growing root tip (Rietjens and Alink, 2003).

The present study indicates that, among the species studied, the weeds (*Bidens pilosa* and *Portulaca oleracea*) were more sensitive to Neem extract than the crops (*Triticum aestivum* and *Zea mays*).This observation is in accordance with that of Al-Sherif *et al.* (2013) who showed that the Egyptian clover and wheat were less sensitive to the extracts of *Brassica nigra* than the weeds *Phalaris paradoxa* and *Sisymbrium irio*. Also, Goamaa *et al.* (2014) reported that the weeds (*Chenopodium murale*, *Brassica nigra* and *Melilotus indica*) are more sensitive to the *Sonchus oleraceus* extract than the crop (*Trifolium alexandrinum*). Omezzine *et al.* (2011) confirmed that the roots of *Thistle* and *Peganum* weeds were more sensitive to the leaf extract of *Inula viscosa* than the roots of Lettuce and raddish crops.

Figure-2. Boxplots showed variations in shoot length of *Zea mays*, *Triticum aestivum*, *Bidens pilosa* and *Portulaca oleracea* treated with aqueous extract of Neem.



The shoot length of *Zea mays* showed stimulation in all extracts after 10 days. The inhibition of *Z. mays* shoot length occurred after 30 days. This result means that the used concentration of this study may be low to cause inhibition of seed germination and seedling growth of *Zea mays* at early stages of growth. These results are in harmony with that of Shruthi *et al.* (2014) who found that the low concentration of Neem aqueous extract (5%) induced a stimulatory response in root and shoot length of *Vigna radiata*. Also, Lawan *et al*. (2011) demonstrated that the germination percentage of some cowpea varieties (Yoro da kokari variety) is more in 10% concentrations of Neem extract compared to control. Ogunyemi and Odewole (2011) found that the low concentrations of Neem extract induced stimulation on *Crotalaria ochroleuca* germination and on the plant height of *Senna sophera*. The stimulation of seedling growth of *Zea mays* with using low concentrations of *Eucalyptus rostrata* was reported by (Hegab *et al*., 2016). They attributed stimulation of the growth of *Z. mays* under low levels of *Eucalyptus rostrata* extracts to the production of phenolics and glycosides by *Zea mays* under these low levels as protective agent which reduce the phytotoxic effects of *Eucalyptus rostrata* allelochemicals. Lim *et al.* (2011) and Swapna Gurrapu (2017) were demonstrated that the presence of many allelocemicals in the environment enhance the defense system in the plant at low concentrations through stimulation of protein synthesis due to increasing incorporation of amino acid into protein in seedling. Similarly, the results agree with those of Rejila and Vijakumar (2011) who showed that the aqueous extract of *Jatropa curas* stimulate the seed germination and shoot growth of *Sesamum indicum*.

The probable reason for the potent allelopathic activity of Neem may be due to the presence of many bioactive secondary compounds in this plant. In our study through GC/mass analysis we confirmed the presence of total phenolic acids (318 mg/gm gallic acid), flavonoids (269.3 mg/gm rutin), saponins (2.07 gm %), tannins and alkaloids (1.77gm % for each). These compounds have been described as allelochemicals (Blum, 2011 and Cheema *et al.,* 2013). Also Qasem and Foy 2001 indicated that various phytochemicals, including phenols, flavonoids, terpenes and alkaloids exhibit strong phytotoxicity. The presence of high levels of secondary metabolites in a given species can enhance its allelopathic potential because many of these compounds interfere with the key enzymes of metabolism (Batlang and Shushu, 2007) and cell division and elongation (Levizou *et al.,* 2002). Several authors have attributed the inhibition of seed and seedling growth to the release of phenolic compounds (Fahmy *et al.,* 2012 and Xu *et al.,* 2013). Chou (2006) attributed the reductions in seedling growth to the involvement of the phenols, which can suppress the synthesis of protein and nucleic acids and inactivate several enzymes in the growing plants. Gomaa *et al.* (2014) and Rajendra Prasad Gujjeti et al (2014) were reported that the detected phenols and flavonoids in *Sonchus oleraceus* play a significant role in the reduction of the seedling growth of some weeds and crops.

CONCLUSION

In conclusion, the aqueous extract of Neem plant showed a potent allelopathic effect on the growth and germination of the weeds (*Bidens pilosa* and *Portulaca oleracea*) and the crops (*Triticum aestivum* and *Zea mays*) but the inhibitory effects was lower in crops than in weeds. Moreover, allelopathic interactions of Neem plant include both stimulatory and inhibitory effects on *Zea mays* plant. The results of the present study revealed that stimulatory and inhibitory effect of Neem aqueous leaf extract may be due to the presence of bioactive secondary compounds (allelochemicals).

Conflict of Interests

Authors declare that there is no conflict of interests regarding the publication of this paper.

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